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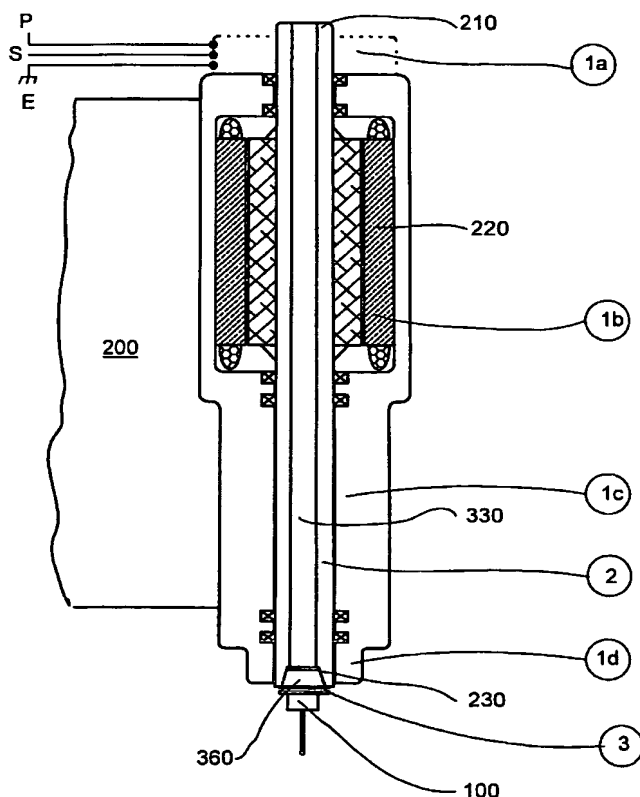
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(54) Title: MACHINE ADAPTATION



(57) Abstract: The invention relates to the transmission of power and/or data from/to a stationary part of a machine tool (200) to/from an accessory (100) mounted in the spindle (210) of the machine tool (200). A first electrical link or interface 1a, 1b, 1c, 1d provides electrical communication between the stationary part (200) and the spindle (210), and a second electrical link or interface (3) is provided electrically connected to the first electrical link at the accessory mounting area (230). The second link (3) is in the form of electrical contacts. The invention extends to an accessory shank (360) for mounting to the spindle (210) of the machine tool, and also to an accessory (100) e.g. in the form of a measurement probe, connected to the said shank (360).



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**MACHINE ADAPTATION**

This invention relates to the transmission of power and/or data within a machine e.g. a machine tool, and  
5 relates particularly, but not exclusively, to apparatus for the supply of power to and data communication with an electrical accessory e.g. a measurement probe mounted on the machine spindle.

10 When an electrical accessory like a measurement probe is located in a machine tool spindle, normally used for cutters, it becomes difficult to supply that accessory with power and to provide a signal path to and/or from that accessory. Batteries have a limited life,  
15 particularly when wireless transmission of large amounts of probing data to a remote receiver takes place. Also it is undesirable to have extra power supply or data transmission parts fitted around the machine's spindle because these parts can interfere  
20 with cutters subsequently located in the spindle, or these parts may collide with a workpiece or automatic cutter changer mechanism.

One example of a machine which includes parts fitted  
25 around the spindle for supplying power to and signal transmission from the machine is shown in US Patent No. 4,339,714. Other similar devices are shown in US Patent Nos. 5,791,836 and 4,536,661.

30 An arrangement for providing a signal path within a machine tool is disclosed in US 5109223. The disclosure shows a machine tool body having a signal path to a rotatable spindle in the form of a first inductive link. Also shown is a second inductive link between the

spindle and a measurement probe across the widest portion tapered shank (5). A probe is mounted to the shank.

- 5 The arrangement of the second link in that patent is not suited to modern machine tools because the wide area at the base of the taper is highly stressed when cutters are being used, due to e.g. high cutter side loading and high spindle speeds. The position of this
- 10 second link means that it is likely to be knocked by cutter shanks being inserted and removed from the shank holder. Thus it would be difficult for a machine tool manufacturer to successfully adapt his existing machine design to incorporate the arrangement illustrated.
- 15 Likewise a new design would require additional strengthening to compensate for the weakness created by the second inductive link illustrated.

- Furthermore the links will not transmit enough power if
- 20 they are too small. So it seems that it is a necessity to position the second link at the larger end of the tapered shank in order to maximise its size. Moreover, use on small tool shanks (30mm diameter or less say) would not be a practical proposition because the link
- 25 at the shank would be far too small to transmit enough power.

- For an inductive link to function effectively the ferrite elements mentioned in US 5109223 should not be
- 30 separated by magnetisable material (e.g. the metal surface of the shank). Consequently an interruption in the surface of the shank would have to be made at the link on the shank for effective operation. Such an interruption would have to be sealed. Sealing of

non-metallic parts to metallic parts is very difficult in the machine tool operating environment at the stressed position indicated in Figure 1 of US Patent No. 5,109,223.

5

The arrangement of Fig 1 in that document requires relative orientation between the tool shank and the spindle. Such orientation is not always possible on machine tools. The arrangement of Fig 2 requires an  
10 annular recess in the shank at the aforementioned highly stressed location.

The transmission of power to the probe is not contemplated in US 5109223.

15

According to a first aspect of the present invention there is provided a machine tool comprising a stationary part and a spindle, the spindle having a shank receiving area for releasably accepting the shank  
20 of a cutter or other machine tool accessory, and comprising a first electrical link between the stationary part and the spindle, and a portion of a second electrical link at the shank receiving area in electrical connection with the first link for providing  
25 in use a disconnectable electrical link between the spindle and the shank, wherein the portion of the second link is in the form of at least one electrical contact.

30 In this description an electrical contact is any part which provides physical conductive contact and thus produces a conductive path across a link for electricity. The first link is described as the first element in the description and the second link is

described as the third element.

According to a second aspect of the invention there is provided a machine tool shank for releasably mounting a machine tool cutter or other machine tool accessory to the spindle of a machine tool comprising a portion of an electrical link in the form of at least one electrical contact.

10 According to a third aspect of the invention there is provided a machine tool accessory having a shank for releasably mounting the accessory to the spindle of a machine tool comprising a portion of an electrical link in the form of at least one electrical contact, the  
15 accessory being supplyable with power, or having a signal path, via the electrical contact.

According to a fourth aspect of the invention there is provided a machine tool comprising a stationary part, a spindle having a shank receiving area, a shank  
20 releasably acceptable to the shank receiving area, and a machine tool accessory attached to the shank, and comprising a first electrical link between the stationary part and the spindle and a second electrical  
25 link at the shank receiving area being in electrical communication with the first link for providing in use a disconnectable electrical link between the spindle and the shank for providing power or a signal for the accessory, wherein the second link is formed as two  
30 portions, one portion being mounted to the spindle the other portion being mounted to the shank, wherein each portion has at least one complementary contact for electrical communication between the two portions.

The invention extends also to a measurement probe as claimed.

Preferably the links mentioned above are used to supply power to the accessory. Preferably the links are used to transmit signals to and/or from the accessory.

The invention will now be described with reference to the drawings, wherein:

10        Fig 1 shows a typical arrangement of a machine tool spindle adapted for the supply of power to, and data transmission both to and from an accessory mounted thereon;

15        Figs 2-11 show various embodiments of apparatus for supplying power to the spindle, and for transmitting data to or receiving data from the spindle;

      Figs 12 and 13 show apparatus for carrying power and signals along a spindle; and

20        Figs 14-24 show various embodiments of apparatus for supplying power or receiving/transmitting data from a spindle to an accessory mounted in the spindle.

Referring to Fig 1, part of a machine tool 200 is shown having a spindle 210 driven directly by motor 220. A cavity or shank receiving area in the form of a tapered housing 230 in the spindle 210 is used to hold a cutter or, as in this illustration, a measurement probe 100. Modern machine tools have automatic cutter changers.

30        Other accessories can be used also in place of a cutter. All will be mounted on a standard tool shank 360. Most standard tool shanks are of tapered (frustum) configuration. With this invention a carousel of cutters together with one or more accessories will be

used and selection of the correct cutter/accessory will be made by a program. When a measurement operation is to be performed then an accessory in the form of a measurement probe will be selected from the carousel  
5 and automatically fitted into the spindle. The machine can be moved into the desired location and the workpiece can be measured, either by translational movement of the spindle or (if the probe itself can move) by keeping the spindle stationary and  
10 manipulating the probe.

In order to provide power and a signal path to the measurement probe 100 or other accessory on the machine tool 200 via rotary components (in this case a  
15 continuously rotatable spindle 210) three elements are required. The first element is an electrical link between the stationary machine 200 and the spindle 210 for providing power and/or signal connections across a rotary interface, the second is a path along the  
20 spindle 210, and the third element is a disconnectable electrical link from the spindle to the probe 100 or other accessory at the shank receiving area 230.

There are a number of positions at which this first  
25 element (variants of which are described in detail below) may be positioned, examples of which are shown in Fig 1 as circled references 1a, 1b, 1c and 1d. Position 1a has been illustrated schematically in chain-dotted lines and provides a rotary link giving a  
30 signal path S, power supply P and (in this instance) a chassis return E.

Reference 1b shows another possible position for the first element. In position 1b it is likely that the



link between the machine and its spindle will be formed within the motor 220 and take the form of a stator and rotor coil as described below.

- 5   References 1c and 1d show other possible positions for the first element which may take the form of any of the links described below with the benefit of complete enclosure.
- 10   Reference 2 indicates the second element i.e. the power and signal path along the spindle joining the first and third elements. Alternative embodiments for this part are described below.
- 15   Reference 3 likewise indicates the position of the third element i.e. the link between the spindle 210 and probe 100 or other accessory. Alternatives for this part are described below also.
- 20   Figs 2-11 show various ways of providing power and signal links from the static machine 200 to a rotating part, in this case spindle 210.

Fig 2 shows a slip ring arrangement having two rings  
25   222 and two wipers 225, one supplying power combined with a signal (P+S) and one forming a common return E. The power and signal supply is intended to be transmitted via an insulated path I along the spindle and the common return E is formed by the remainder of  
30   the spindle. Three or more slip rings could be used e.g. for separate power and signal paths.

Fig 3 shows another machine to spindle link in the form of an inductive rotary transformer. In this variant an

alternating current is passed through static transformer windings 235 and is picked up by rotary coil 230. One set of windings only is used in this arrangement but more may be used e.g. a pair of sets.

5 In the present arrangement the power and signal P and S are combined in one alternating current sent to accessory 100 via insulated spindle track I, and returned via spindle path E. This rotary transformer is more robust when very high spindle speeds are used  
10 e.g. 50,000 rpm, because the coils of the transformer will be pushed centripetally against side walls 250 in use. These walls will support the coils during rotation.

15 Fig 4 shows another machine to spindle link in the form of a single coil rotary transformer which has an axially spaced stator 245 and rotor 240. This arrangement operates in a similar manner to the rotary transformer shown in Fig 3.

20

Fig 5 shows a machine to spindle inductive link in the form of a multiple coil rotary transformer having rotary and stationary parts 252 and 253 respectively. In use a separate power and signal path can be  
25 utilised, in which case two insulated paths IP and IS will be required on the spindle. A common spindle return E is used here.

Fig 6 shows another machine to spindle link this  
30 variant employs a rotary transformer having a stator 265 and a rotor 260 in combination with a capacitance link which likewise has a stator part 275 and a rotor part 270. A signal S is passed via the capacitance link and power is supplied via the rotary transformer.

The spindle has two insulated paths IS and IP and a common return E.

Fig 7 shows a machine to spindle link which is solely  
5 capacitive. A stator 290 is shown and a rotor 295. In  
this example there is a power path P-IP and a separate  
signal path S-IS as well as a common return E. The  
power path will have to have a relatively high  
capacitance and so the surface area of the capacitive  
10 plates 280 should be larger in comparison to the area  
of the signal path plates 285.

Fig 8 shows another capacitive machine to spindle link.  
This variant has radially extending plates 297/300 to  
15 provide more surface area than might be achievable with  
the circumferentially extending plates illustrated in  
Figs 6 and 7. This example functions in the same  
manner as the capacitive link shown in Fig 7 and  
described above. Shown is a stator 297 and a rotor 300.

20

Fig 9 shows yet another machine to spindle link. In  
this example a rotary transformer 310 is used for power  
transmission. A signal path IS is provided by an  
optical fibre 315 in the spindle co-operating with an  
25 optical machine module (OMM). The signal path in the  
spindle is via the optical fibre 315 which rotates in  
use. A small gap for light to cross is present between  
static OMM and rotary parts of the spindle. Thus a  
rotary link is formed for a signal. An optical  
30 transceiver in the spindle or accessory may be provided  
for two-way communication along the fibre 315.

Figs 10 and 11 show examples of optical fibre to OMM  
links. Fig 10 shows a fibre 315 which can transmit

and/or receive data via a static axial emitter/sensor 320. Fig 11a shows a y-shaped fibre 315 which can transmit and/or receive data via a ring of static emitters/sensors 325 disposed circumferentially about the ends of the y-shaped fibre 315. Fig 11b shows a fibre 315 merging into a disk 316 which again can transmit and/or receive data via a ring of static emitters/sensors 325.

10 The electrical link shown in Fig 2 is a contact link whereas the electrical links shown in Figs 3-11b are all non-contact links.

Figs 12 and 13 illustrate examples of the second element and show sections through spindle 210, having a draw-bar bore 330. Each Figure shows two insulated paths IS and IP for signal and power respectively, as well as a common return E formed by the remainder of the spindle. Two wires are used in these examples for dynamic balancing of the spindle. A combined signal and power path might be used so one wire only would then be required. A counterweight or asymmetric section might be used to provide a balanced shaft if only one wire was present. Shown are two insulated wires but more than two wires may be used.

25 Alternatively or additionally one or more optical fibres may form the required signal path. Optical fibres may be omitted entirely, so a straight line light path may be provided between the machine to spindle link and the electrical device.

The electrical paths IS and IP may be formed by any distinct conductive path e.g. by flexible conductive strips possibly in a groove or grooves, or curled up

inside the central draw-bar bore 330. The power and signal paths may be formed by an insulated draw-bar, a discrete strip of conductive plating formed on the spindle or draw-bar, or concentric insulated tubes within the spindle or within the draw-bar.

Figs 14a,b and c show an example of a third element of the invention i.e. the disconnectable link between the spindle and the electrical device. Fig 14a is a cross-section through the end of spindle 210 showing a probe 100 within the tapered housing of the spindle. Fig 14b is an enlarged partial view of Fig 14a and Fig 14c is a section through the spindle 210 at 14c-14c in Fig 14a.

In this example probe 100 is supplied with power as well as a signal path via a spring-loaded contact 340 at the spindle in communication with an insulated circumferential track 350 on the probe 100. The tapered fitting of the probe allows direct contact of the probe with the spindle e.g. at surface 360 thus providing a common chassis return for the power and signal.

Alternative positions for the spring contact 340 are shown at A. In this example only one spring contact 340 is shown. However, for balance a dummy contact 345 (Fig 14c) might be employed. Further, more than one spring contact 340, in combination with two or more insulated circumferential tracks 350 may be used e.g. for separate power and signal paths (e.g. 340', 350' shown in chain-dotted lines in Fig 14c. The spring contact(s) 340(340') may be provided in the shank 100, and track(s) 350 may be provided at the spindle 210. The tracks 350, 350' may be part circumferential.

Fig 14d shows a variant of the probe illustrated in Figs 14a,b&c. In this variant, instead of insulated tracks 350, the shank 360 of the probe is divided (into quadrants 61,62,63 & 64 in this instance). Each  
5 division has its own sprung contact as described immediately above. Such a contact will be disposed in the position shown in Fig 14a or the positions A.

10 Instead of tracks 350 shown in Figs 14b and c, the shank might be divided by insulating tracks 361 into a number of discrete areas. In this instance four contacts would be arranged on the spindle at 90° to each other so that they coincided with the quadrants.

15 Fig 15 shows two alternative spindle to probe links. In this illustration one example is shown on the left side of the centre line and a second example is shown on the right side of the centre line. In each case electrical insulation between parts is indicated by  
20 thick lines.

On the left side a combined signal and power path IS/IP is shown incorporated into a draw-bar 333. An insulated portion of the draw-bar 335 in use contacts  
25 an insulated section 334 of the probe 100. Thus the path of the power and signal is kept electrically separated from the remainder of the spindle, draw-bar and probe. The chassis forms the return path E.  
On the right side are shown separate signal and power  
30 path IS and IP. In this example the draw-bar 333 has two insulated portions 336 and 337. These portions are in communication with an insulated element 338 and a spring contact 339 respectively each on the probe 100. Again electrically separated paths are formed between

the signal draw-bar and the probe and the chassis forms the return path E.

Fig 16a shows an alternative link from the spindle to the probe. In this example use is made of a coolant channel 331 within the draw-bar 330. This channel is unused when the probe 100 is mounted in the spindle. The channel incorporates, in this example, two rings 366 and 367 which co-operate with two spring contacts 368 and 369 mounted on a plug 365 which blocks the coolant channel 331. Wiper ring 370 acts to remove any coolant from the rings 366 and 367 when the probe is inserted into the spindle, and prevents drips reaching the contacts during operation of the probe. A chassis return E is used in this example also. Fig 16b shows an enlargement of the parts of the link. Plug 365 could be hollow to allow coolant feed for other accessories.

Fig 17 shows yet another example of a link to the probe from the spindle. In this example separate signal and power paths are provided. Draw-bar 330 has concentric inner and outer parts 330S and 330P respectively, which are insulated from each other and from the spindle 210. Thus the inner part of the draw-bar 330S provides a signal path and the outer part 330P provides a power path, while the spindle forms a return. Ring 367 on the inner draw-bar part, in use, is in electrical communication with spring contact 369 on the probe, thus linking the draw-bar and the probe with a signal path. Insulated portion 335 on the outer draw-bar part in use, is in electrical communication with insulated section 334 on the probe and links also the draw-bar and the probe with a power path. The spindle forms a chassis return.

The links shown in Figs 14a to 17 are contact links, but the spindle to probe electrical link may be non-contact e.g. capacitive or inductive and may take the form similar to the links described for the first element, as illustrated in Figs 3 to 9.

Fig 18 shows an embodiment having first (1d), second (2) and third (3) elements at the base of the machine 200 illustrated in Fig 1. In more detail there is shown an inductive link 10 providing power and signal transmission between machine 200 and spindle 210. A path through the spindle, for the power and signal, is provided in the location of the dotted line P/S. The tapered housing 230 of the spindle 210 incorporates contacts 18 that communicate electrically with complementary contacts 20 on tapered shank 360. The complementary contacts 20 are electrically connected to the accessory 100 to be fitted to the shank 360.

It will be noted that the link between the spindle and the shank is positioned at the rear of the shank housing 230. In that position the link e.g. the contacts, in the housing is unlikely to be damaged when cutters or accessories are inserted or removed from the housing. Also the stresses in the spindle are far less than they are at the front of the housing so a larger link can be used and there is no risk of mechanical failure of the spindle. The advantages mentioned above arise when the link (not necessarily of the contact type) is positioned in the rear third of the housing. However, those advantages are evident when the link is placed in the rear half of the housing. Use of contacts allows a greater transfer of power between the spindle and shank than can be achieved with the same size non-



contact (e.g. inductive) link.

A scheme of the electrical paths for this embodiment is shown in Fig 23 and is described below.

5

Fig 19 shows shank 360, spindle mounted contacts 18 and shank contacts 20. In this embodiment the contacts are two sets of "C" shaped rings 21/22 & 24/25 of sprung metal, each forming part of an electrical path to an accessory 100 (not shown). Rings 22,24 are mounted to the shank in a resilient electrically insulating material 26 e.g. an elastomeric material like vulcanised rubber or flexible polyurethane. The spindle contacts are situated toward the top of the tapered portion of the shank. The spindle contacts 21/25 are mounted in a non-conductive rigid plastics block, in two pairs on each side of the shank. They extend in an arc of approximately 50-90° around the rings 22/24. A complete ring around the shank is possible also. The electrical path to an accessory to be mounted to the shank is via conductors in through-holes in the shank (not shown). The shank shown in Figs 18&19 has the proportions of what is known as a BT40 type shank.

25 The contacts 21/25 are non-protruding and recessed so that a standard tool shank does not interfere with the contacts when a tool is used in the spindle.

Fig 20 shows a similar configuration to the embodiment shown in Figs 18&19. The shank illustrated in Fig 20 is what is known as an HSK shank, otherwise the arrangement of the parts is similar to that shown in Fig 18. The arrangement of the contacts 28/30 is similar to the contacts shown in Figs 18&19. They are

30

constructed from the same materials and they are situated in the same place and therefore have the same advantages as the contacts mentioned immediately above. The contacts are shown in more detail in Figs 21 and 22.

Fig 21 shows a (HSK) shank 360 and accessory (probe) 100 attached thereto. Contact pair 30 is shown having conductive tracks 24 mounted in a non-conductive elastomeric material 26. A similar pair (not shown) is disposed on the opposite side of the shank. Again communication to the accessory 100 is via internal through-holes.

Fig 22 shows a detail of the contacts 28/30 illustrated in Fig 20. A "C" shaped plastics block 29 on each side of the spindle 210 houses contacts 28 formed by a pair of rigidly mounted metal "C" shaped rings 25 which communicate with contacts 24 on the shank. A similar contact block will be disposed on the opposite side of the spindle and will communicate with a respective contact pair at locations opposite to locations 21 shown in the Figure. The elastomeric material is shown removed for clarity, and two insulated conductors 35 which carry power or signal to the accessory can be seen.

The contact block may be offset to accommodate non-oriented shanks.

Figs 23a and 23b illustrate a section through a contact set that could be used with the embodiments illustrated in Figs 18-22. Fig 23a shows the contacts separated, whereas Fig 22b shows the contacts forming a conductive

path. The contacts have a similar construction to that illustrated in Fig 19, and like parts have like reference numerals. Two contact blocks 18 will be provided in opposed positions, each of which are removable and are secured by means of a "C" clip. Contact block 26 is formed from elastomeric material, which is resiliently deformable, as a result of the contacts 22 and 24 being pushed inwardly when the shank 360 is pulled into the shank housing 230 on the spindle 210. The elastomeric material will bulge in the direction of the arrows shown in Fig 23b. This bulging results in a displacement of any residual coolant etc around the contacts. It will be appreciated that the elastomeric material could be used on the outside contact block 18 or on both blocks 18 and 26. Preferably the contacts 22 and 24 are resiliently mounted so that they are forced outwardly against outer contacts in the spindle 210, when the spindle rotates, the outer contacts being rigid.

20

Figure 24 is a schematic representation of the electrical principle used in the embodiments illustrated in Figs 18 to 22. Two inductive links are used to provide communication between the static housing and the rotating parts of the spindle, one for power and one for signalling. Shown also are two contact sets 21/22, 24/25 for communication between the spindle and the shank. Rotatable parts of the link are shown within the area bounded by the dotted line. Each inductive link is formed by a closely spaced pair of annular ferrite rings 40/50 (these are "U" shaped in the embodiments shown in Figs 18 & 20) each of which has a conductor coil 45/55 associated therewith. The ferrite rings and coils together form the non-contact

inductive link between the stationary machine 200 and the spindle 210. The ferrite rings and coils may rotate relative to each other. The two sets of ferrite rings/coils have different diameters DP & DS so one set can be positioned within the other. This means that space in the axial direction of the machine can be conserved. The separation between inductive elements has been shown as cylindrical about the rotation axis of the spindle. However separation in a plane perpendicular to the axis is possible.

The advantages of supplying power and/or providing a signal path to a measurement probe via the machine to which it is mounted are:

- that little or no internal power is required in the probe;
- a lack of a battery compartment and transmission module enables the probe to be more compact;
- an operator is not required to change batteries;
- the contact, inductive or capacitive signal links described are less likely to suffer external interference than radio or light data transmission systems used outside the machine's spindle; and
- since no parts external to the machine are used then, when the probe is not in use, there are no residual parts to interfere with the other operations of the machine.

Whilst the invention has been described with reference to its application to a machine tool and measurement probe, it has many other applications and so is not intended to be limited to this field. For example the invention may find use in any machine which is adapted to accept an electrical device at a rotary machine part

and which is capable of supplying power or a signal path to or from the device.

Examples of accessories other than probes that may be  
5 used with the rotary part described include: a robotic gripper or workpiece manipulator; a laser deburring tool (possibly articulatable); a laser  
driller/profiler/engraver/surface hardener; a camera  
e.g. for measuring surface finish or for monitoring  
10 tool breakage; adjustable size tooling, workpiece cleaners (e.g. vacuum cleaners); electromagnets; high speed motors (e.g. for deburring use) or a tool having supplemental equipment, such as wear, deflection, breakage, identification or usage recording devices.

15 Examples of different probes that might be used include: scanning probes e.g. analogue probes or data streaming probes; touch trigger probes; non-contact probes e.g. camera or laser probes or surface texture  
20 probes. Additionally probes could be articulated by mounting a movable probe head to the shank mentioned above.

The accessory may include data storage and the data may  
25 be read or rewritten. Data stored could include identification and, where a tool and supplemental equipment is used, tool geometry or usage information.

The description and claims refer to a shank. Herein  
30 the word shank is intended to embrace any coupling (e.g. male or female) which is suitable for removable coupling of a rotatable part of a machine to an accessory.

There are presently several standard tool shank designs i.e. the part of the tool which fits into the end of a machine tool's spindle. The probe 100 shown in Figs 1&14-23 illustrates only two types of shank (HSK & BT40). As a consequence any accessory used in place of the tool e.g. a probe, may require several different shanks to fit all the machines which have spindles adapted to supply power or to carry a signal. Thus a feature of this invention is the shank itself, i.e. coupling between the accessory and the rotatable part of the machine which, whilst illustrated as being a shank integral with the probe in some Figs may be a separate item which is selectable from a number of designs to suit the machine on which the accessory is to be used, but which will have the ability to transmit power to the accessory and/or will provide a signal path.

The shanks described herein and illustrated are intended to fit to a machine in use. However they may also be employed off the machine. For example the contacts on the shank may be used to provide pre-heating current for keeping a measurement probe or the like warm whilst it is off the machine, so that no thermally-induced errors in measurement occur. Another example is the uploading of tool data into a tool via the contacts e.g. geometry, tool set information, expected usage, number of teeth etc., before fitment to a machine.

30

The claims refer to a spindle. Herein the word "spindle" is intended to embrace any continuously rotatable part on a machine tool suitable for rotatably driving and holding a tool.

The word "link" used in the description and claims is intended to embrace all electrical interfaces, serial or parallel, singular or plural path, contact or non-contact.

5

Whilst power supply together with signal paths have been described and illustrated it will be apparent that the invention extends to the provision of power alone, the provision of a signal path alone (to an electrical  
10 device, from that device, or both ways) or the provision of both power and a signal path, either together or separately. Separate power and signal paths are preferred because there is then less likelihood of harmonic distortion of the signal.

15

The signal is preferably transmitted at a frequency of between 1 and 100MHz. This range results in low losses. The power is preferably transmitted as a.c. at a frequency of more than 20KHz (approximately 100KHz  
20 being preferred). At this frequency, or greater, little electrolytic corrosion takes place between any contacts used. In order to reduce corrosion on contacts still further, the contacts can be made from Tungsten. Despite the lack of corrosion when using  
25 a.c. at a frequency of 20KHz or above a short pulse of power could be used to remove any corrosion during use, particularly in the signal paths S.

**CLAIMS**

1. A machine tool comprising a stationary part and a spindle rotatable relative to the stationary part, the spindle having a shank receiving area for releasably accepting the shank of a cutter or other machine tool accessory, and comprising a first electrical link between the stationary part and the spindle, and a portion of a second electrical link at the shank receiving area in electrical connection with the first link for providing in use a disconnectable electrical link between the spindle and the shank, wherein the portion of the second link is in the form of at least one electrical contact.
2. A machine tool according to claim 1 wherein the first link and the portion of the second link are arranged to transmit either power or signals, or both power and signals.
3. A machine tool according to claim 1 or 2 wherein the first link and the portion of the second link each have two paths, one for the transmission of power and the other for the transmission of signals.
4. A machine tool according to claim 1,2 or 3 wherein the first link is an inductive link having complementary inductors which in use of the machine have relative displacement, one of the inductors being mounted to the spindle and the other of the inductors being mounted to the stationary part.
5. A machine tool according to any one of claims 1-4 wherein the receiving area is in the form of a cavity



having an opening and a rear area furthest from the opening and wherein the portion of the second link is disposed closer to the rear area than to the opening.

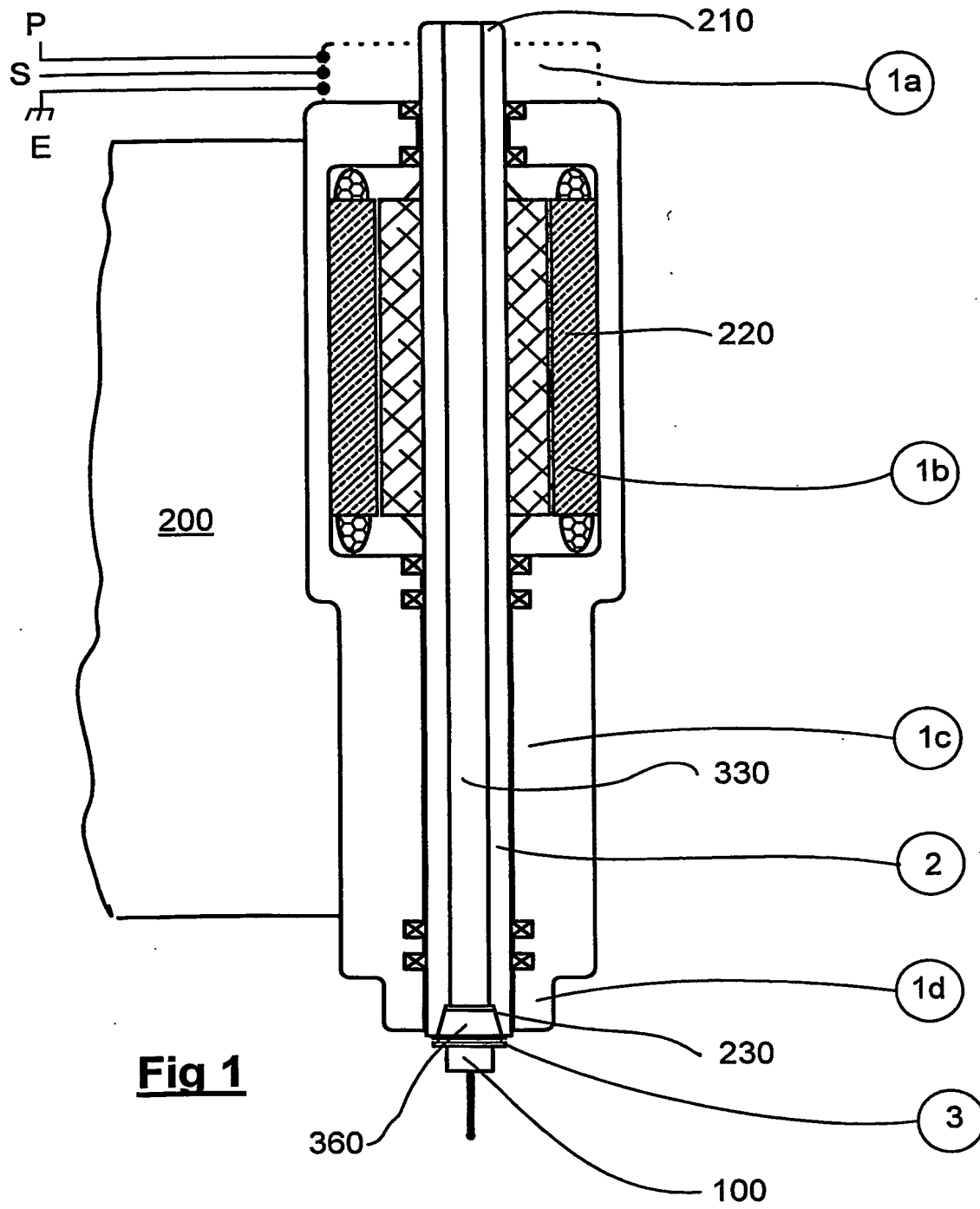
- 5    6.    A machine tool according to claim 5 wherein the portion of the second link is disposed at the rear third of the cavity.
7.    A machine tool according to any preceding claim,  
10    wherein the at least one electrical contact is in the form of a "C" shaped conductive element mounted to a non-conductive block at the shank receiving area.
8.    A machine tool according to claim 7 wherein the  
15    block is releasably held at the area.
9.    A machine tool shank for releasably mounting a machine tool cutter or other machine tool accessory to the spindle of a machine tool comprising a portion of  
20    an electrical link in the form of at least one electrical contact.
10.   A machine tool shank according to claim 9 wherein the at least one electrical contact is in the form of a  
25    conductive element and a resilient support supporting the conductive element.
11.   A machine tool shank according to claim 9 or 10 wherein the shank comprises an end closest to a  
30    location for attachment of the machine tool cutter or other machine tool accessory and an end distal from the location, wherein the said at least one contact is closer to the distal end than to the end for the said attachment.

12. A machine tool shank according to claim 11 wherein the said at least one contact is in the third of the shank closest to the distal end of the shank.
- 5 13. A machine tool accessory having a shank for releasably mounting the accessory to the spindle of a machine tool comprising a portion of an electrical link in the form of at least one electrical contact, the accessory being supplyable with power, and/or having a  
10 signal path, via the at least one electrical contact.
14. A measurement probe having a shank for releasably mounting the accessory to the spindle of a machine tool comprising a portion of an electrical link in the form  
15 of at least one electrical contact, the accessory being supplyable with power, and/or having a signal path, via the at least one electrical contact.
15. A machine tool comprising a stationary part, a  
20 spindle rotatable relative to the stationary part having a shank receiving area, a shank releasably acceptable to the shank receiving area, and a machine tool accessory attached to the shank, and comprising a first electrical link between the stationary part and  
25 the spindle and a second electrical link at the shank receiving area being in electrical communication with the first link for providing in use a disconnectable electrical link between the spindle and the shank for providing power or a signal for the accessory, wherein  
30 the second link is formed as two portions, one portion being mounted to the spindle the other portion being mounted to the shank, wherein each portion has at least one complementary contact for electrical communication between the two portions.

16. A machine tool according to claim 15 wherein either one or both of the or each complementary contacts is resiliently mounted.
- 5 17. A machine tool according to claim 15 or 16 wherein one of the complementary contacts is non-protruding.
18. A machine tool according to any one of claims 15-17 wherein the receiving area is in the form of a  
10 cavity having an opening and a rear area furthest from the opening and wherein the second link is disposed closer to the rear area than to the opening.
19. A machine tool according to claim 18 wherein the  
15 second link is disposed at the rear third of the cavity.
20. A machine tool according to claim 15 wherein alternating current passes through the first and second  
20 links at a frequency greater than approximately 20KHz.
21. A machine tool according to claim 20 wherein the frequency is approximately 100KHz.
- 25 22. A machine comprising a stationary part and a rotatable part continuously rotatable relative to the stationary part, the rotatable part having a coupling receiving area for releasably accepting the coupling of a tool or other accessory, and comprising a first  
30 electrical link between the stationary and rotatable parts and a portion of a second electrical link at the shank receiving area being in electrical connection with the first link for providing in use a disconnectable electrical link between the rotatable

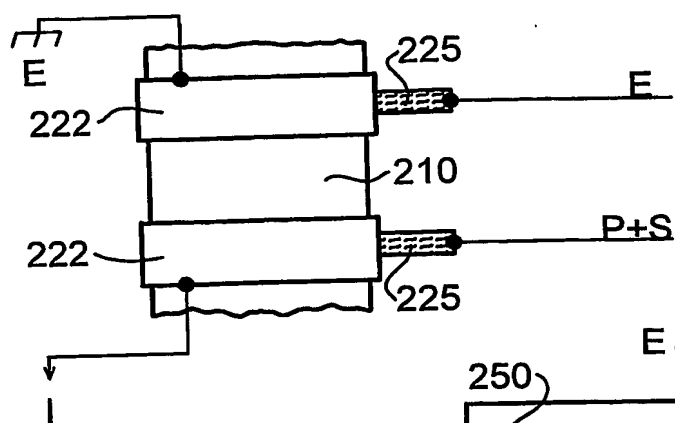
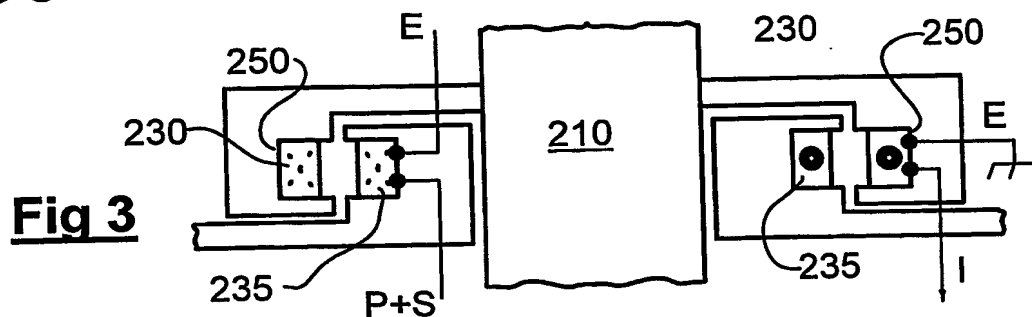
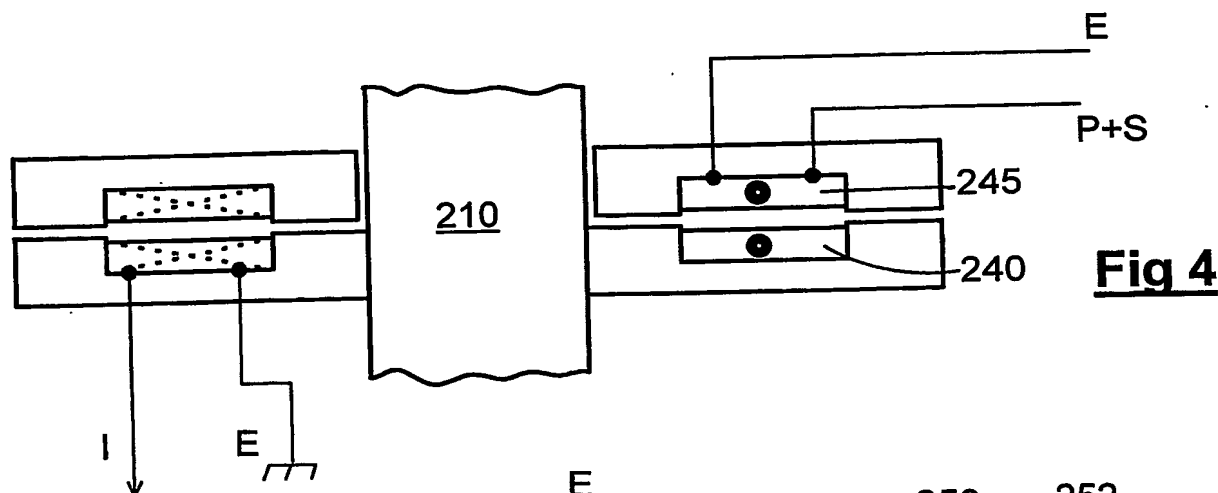
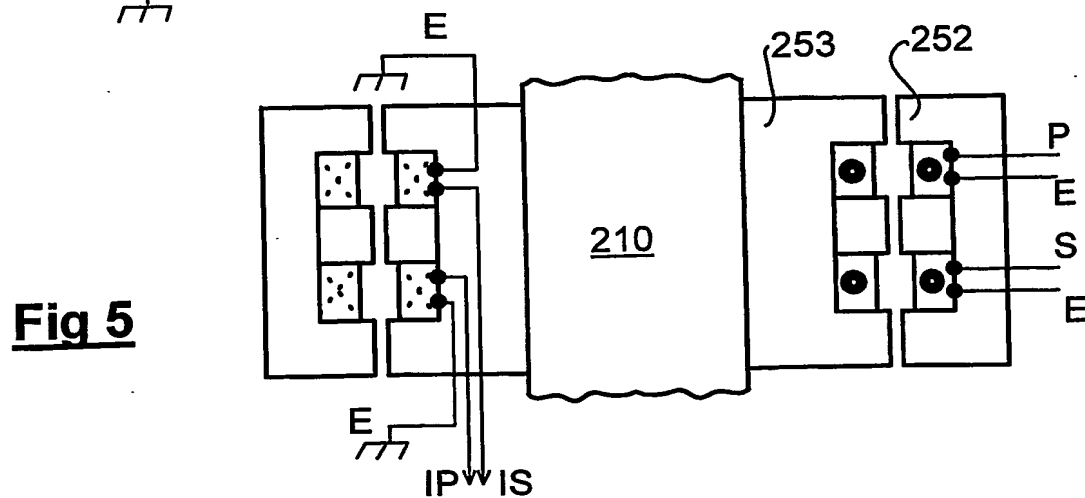
part and the coupling of the tool or other machine accessory, wherein the portion of the second link is in the form of at least one electrical contact.

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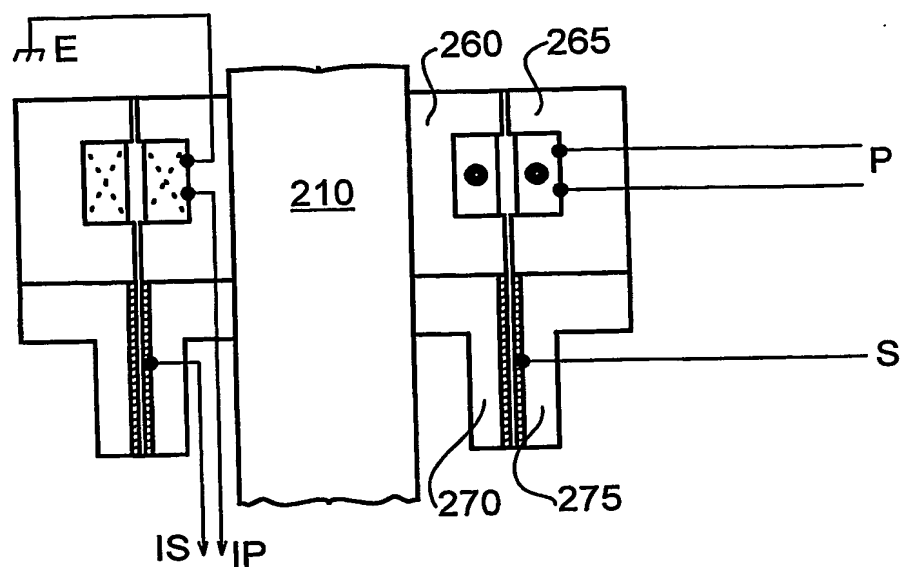
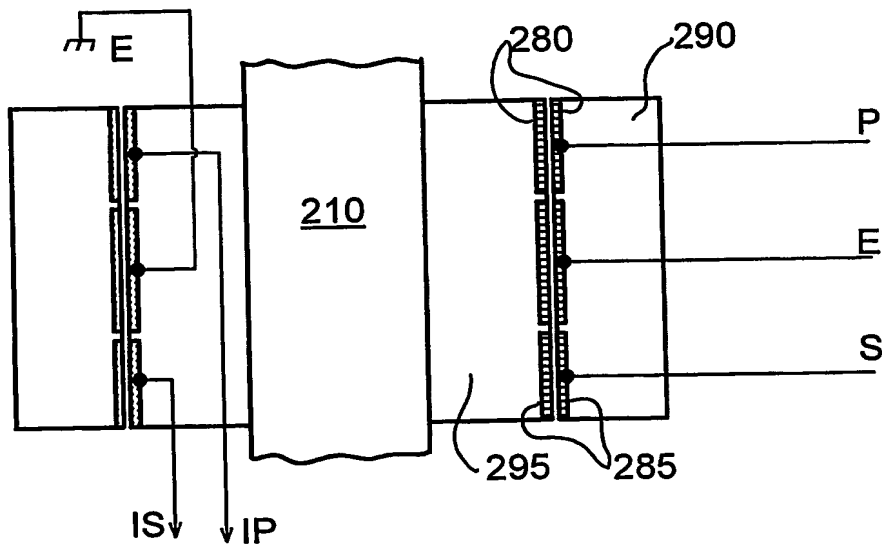
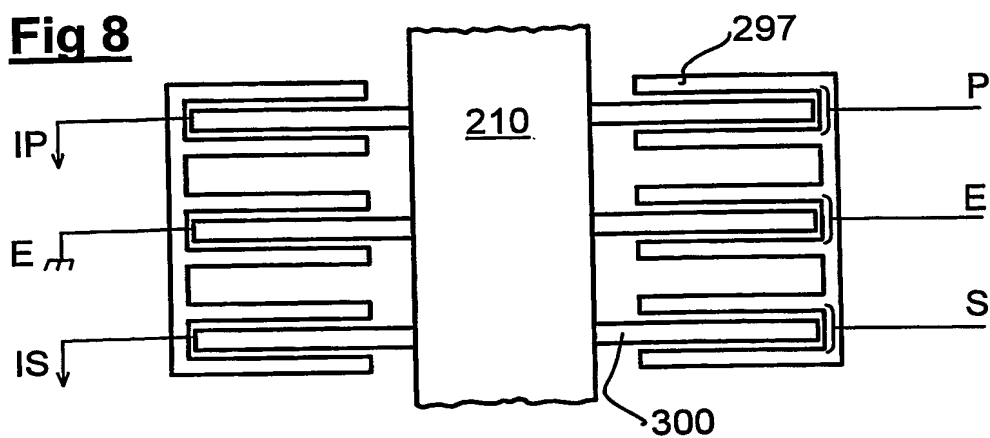


**Fig 1**

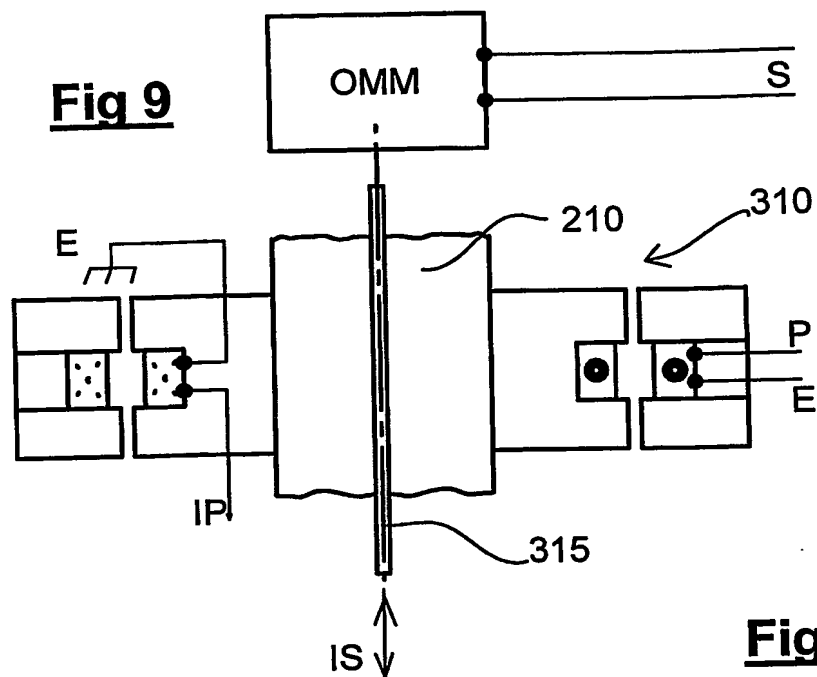
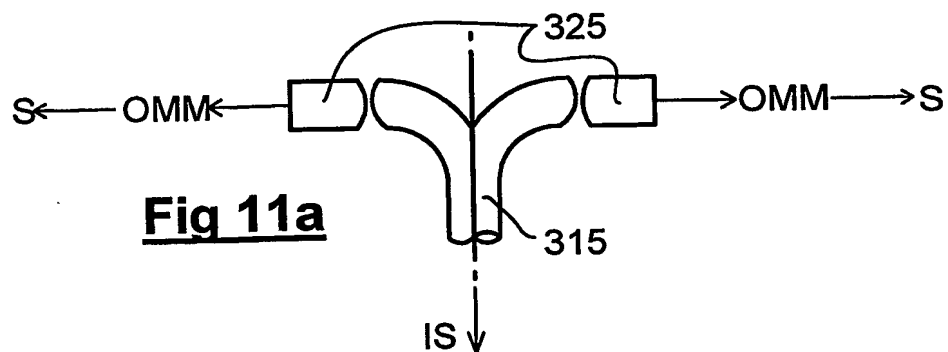
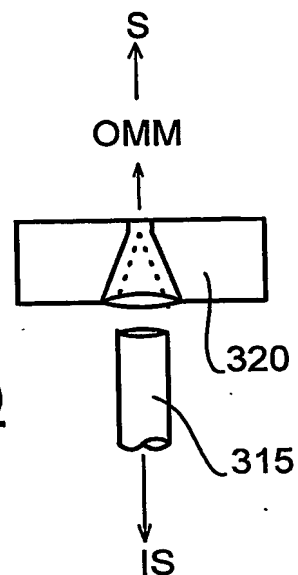
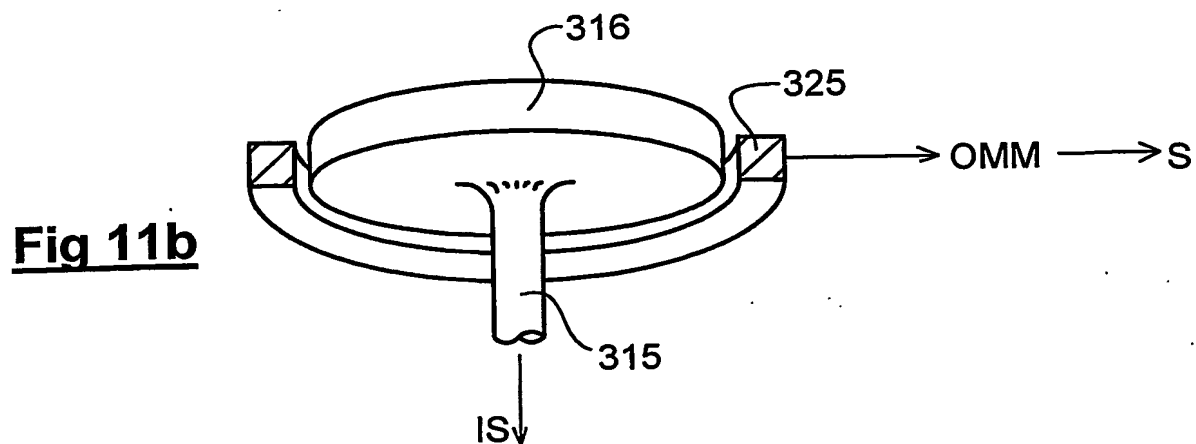
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**Fig 2****Fig 3****Fig 4****Fig 5**

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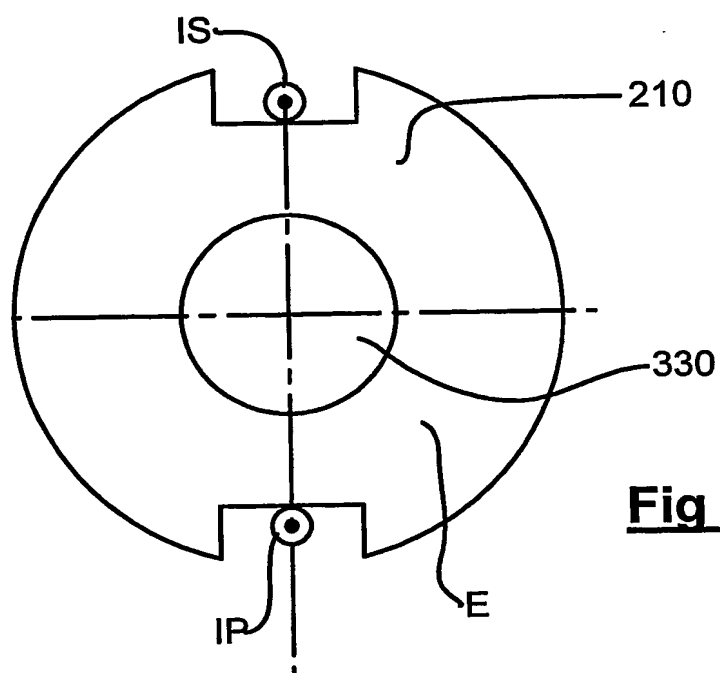
**Fig 6****Fig 7****Fig 8**

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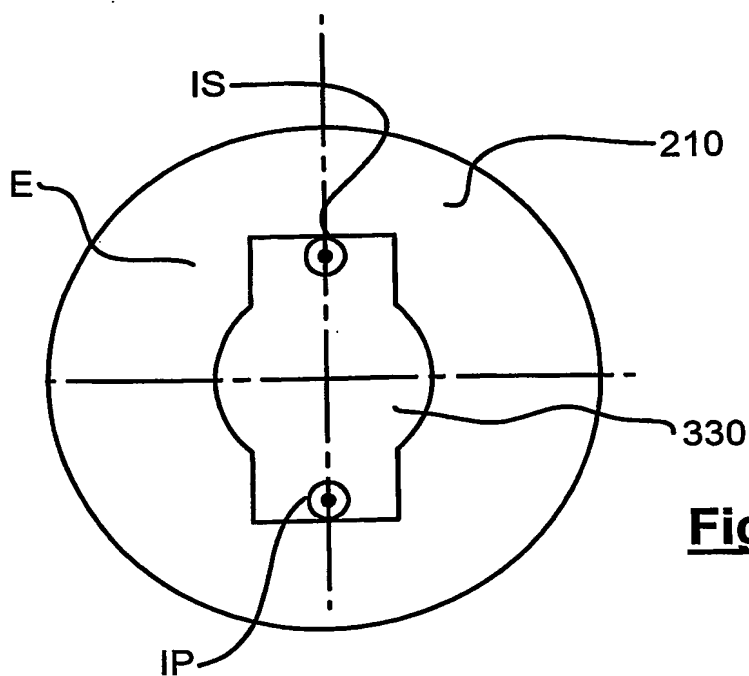
**Fig 9****Fig 10****Fig 11a****Fig 11b**



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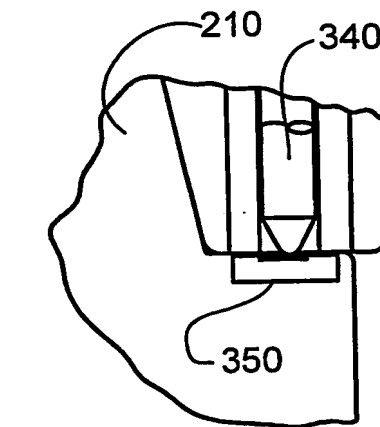
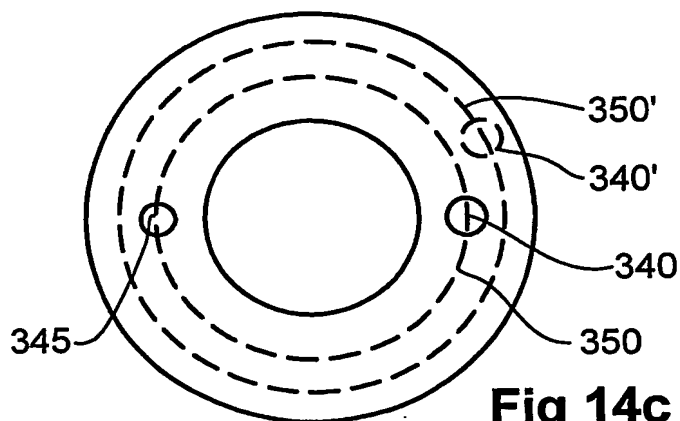
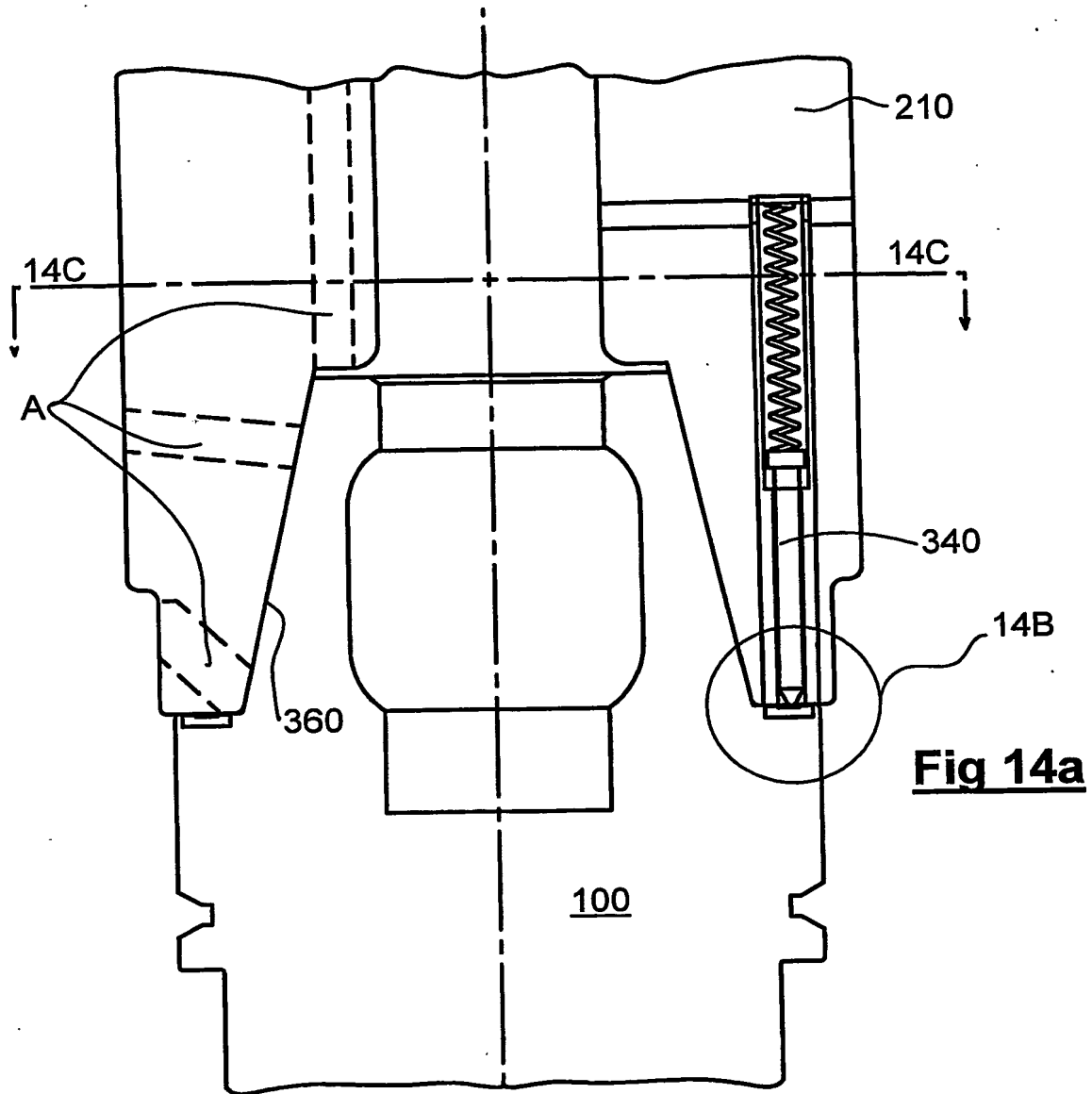


**Fig 12**



**Fig 13**

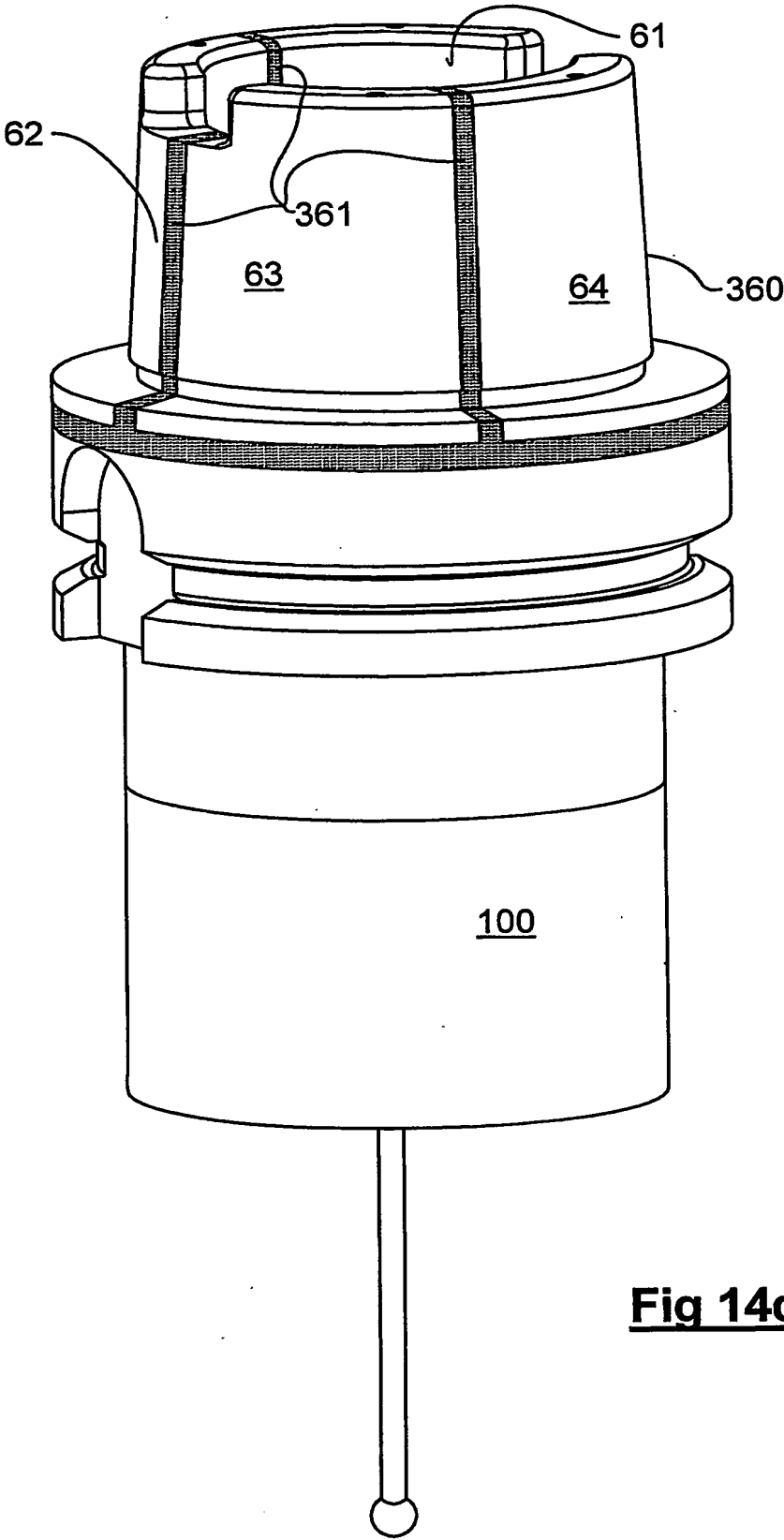
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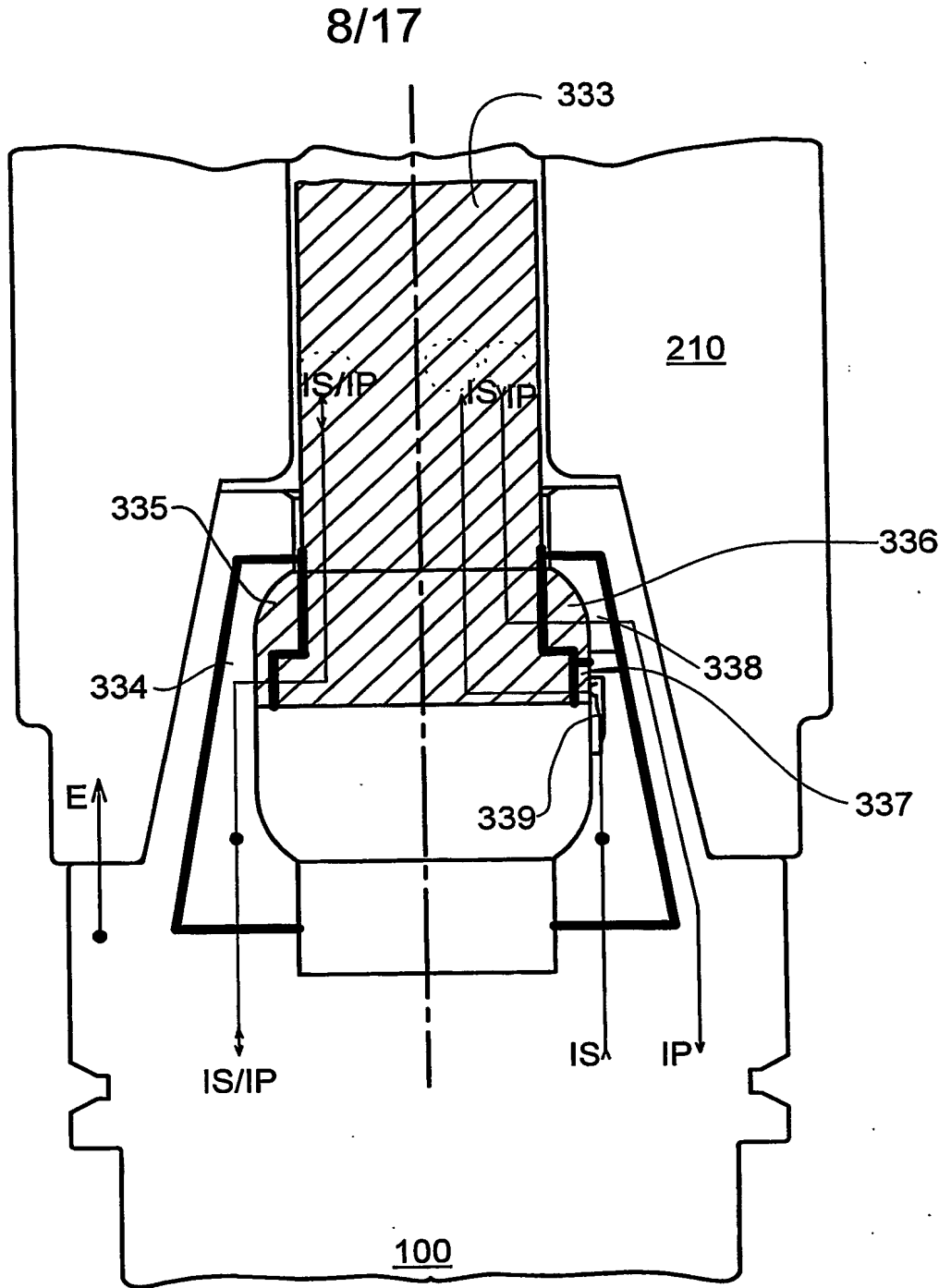
**Fig 14c**

**Fig 14b**

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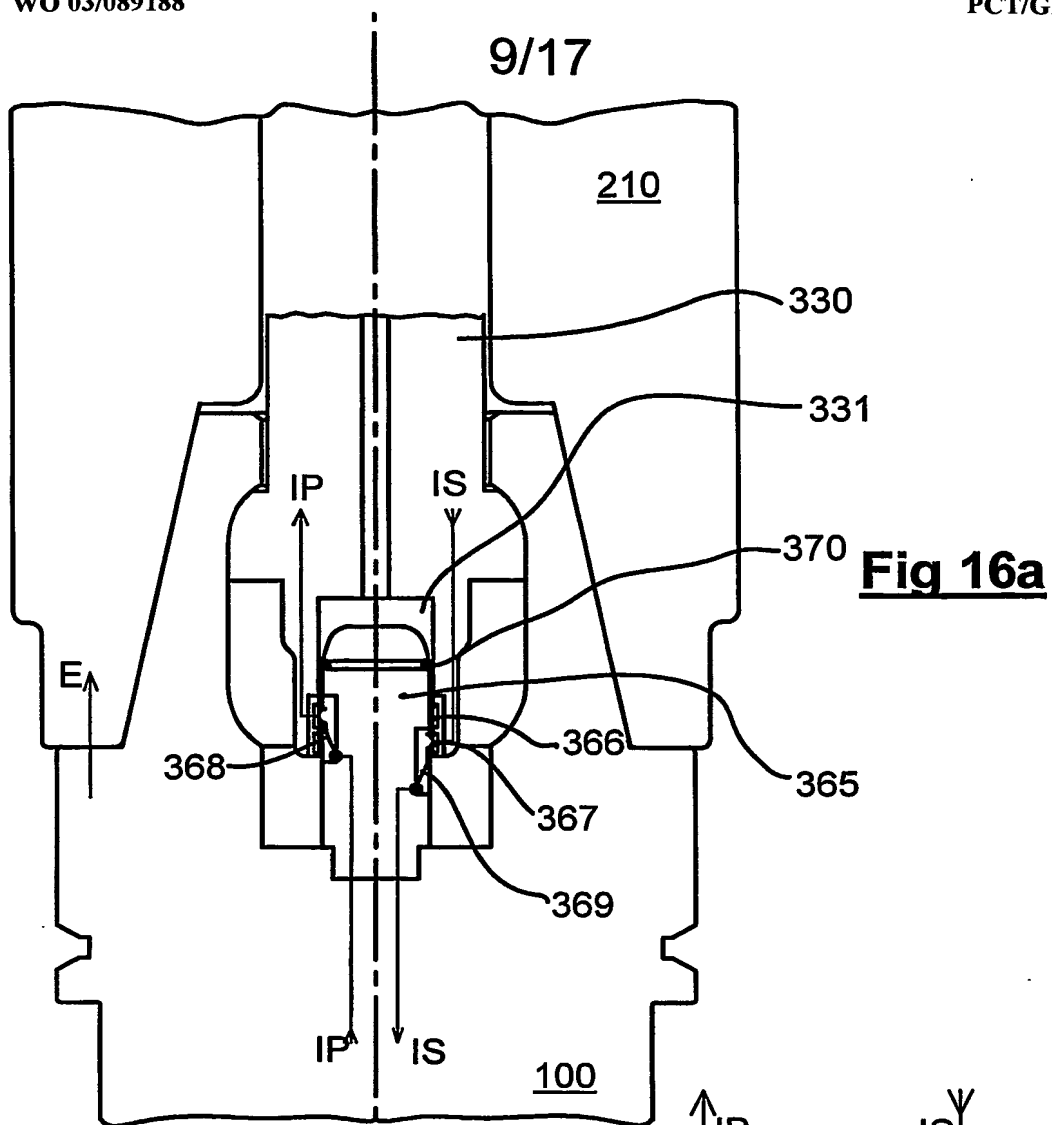


**Fig 14d**

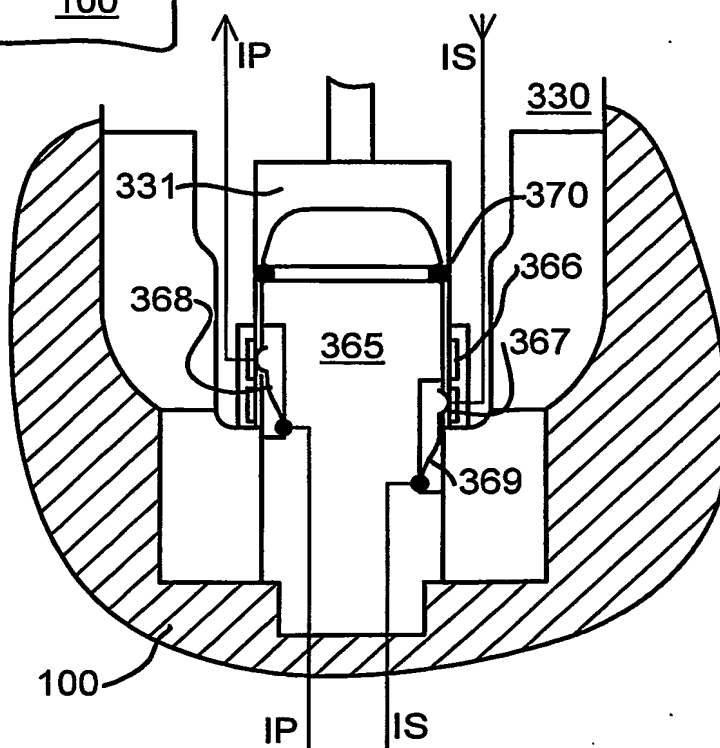


**Fig 15**

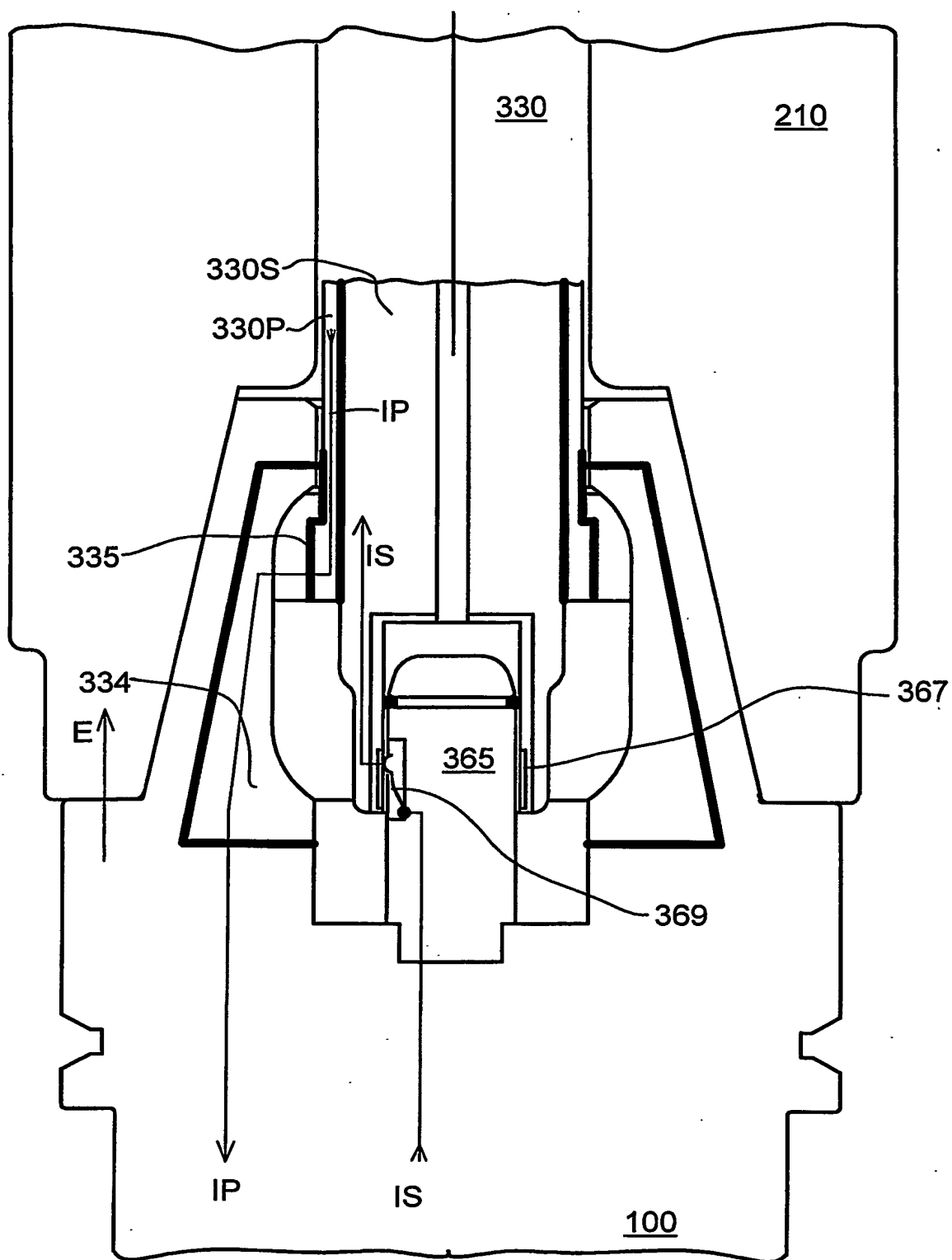
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**Fig 16b**

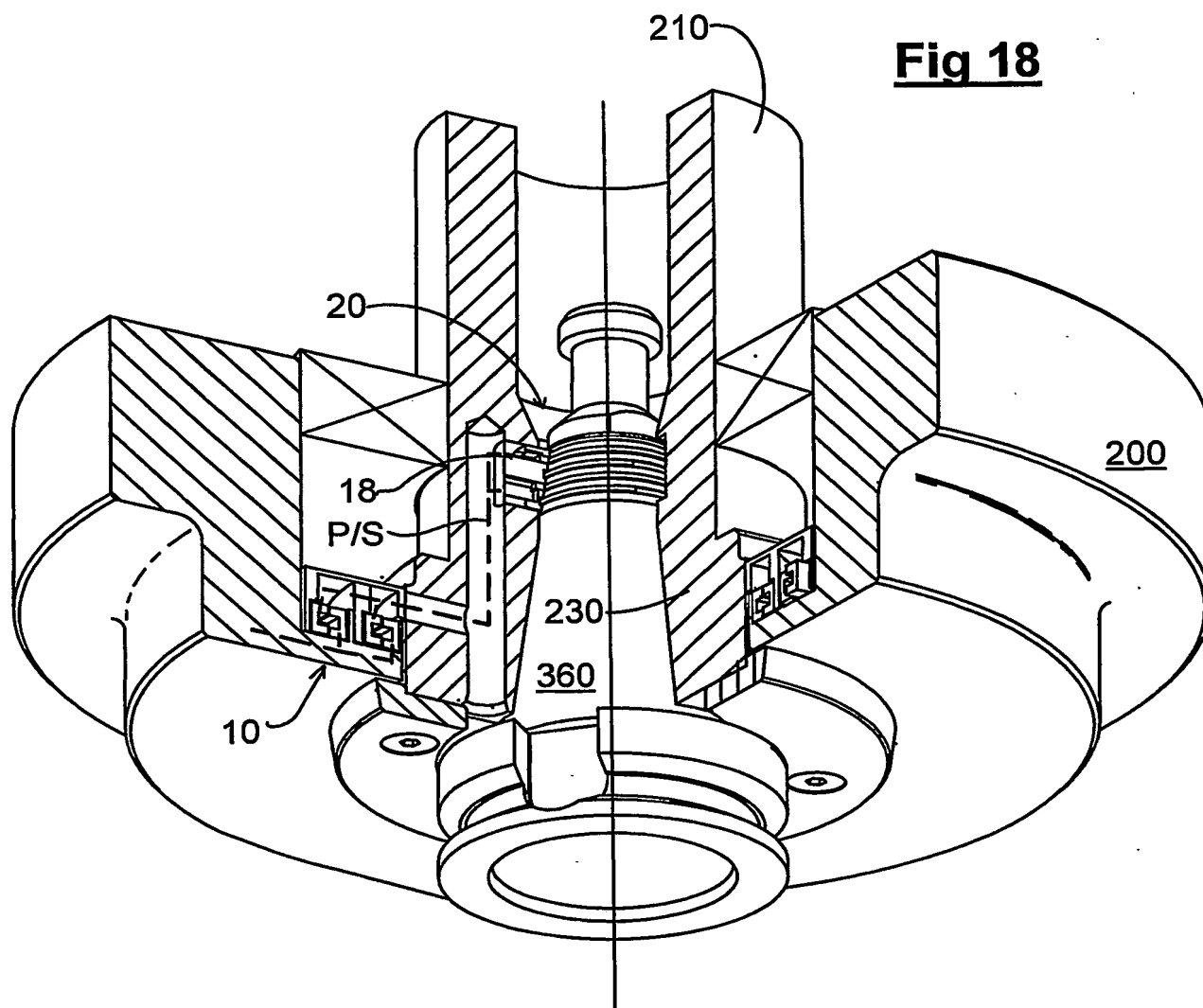


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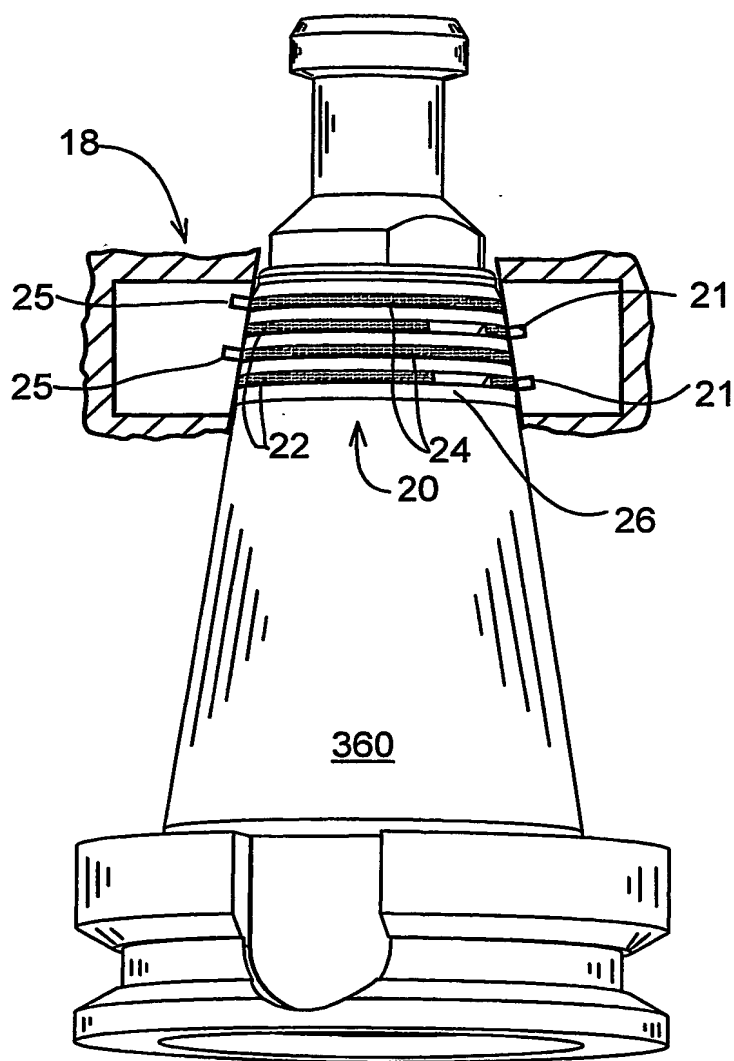


**Fig 17**

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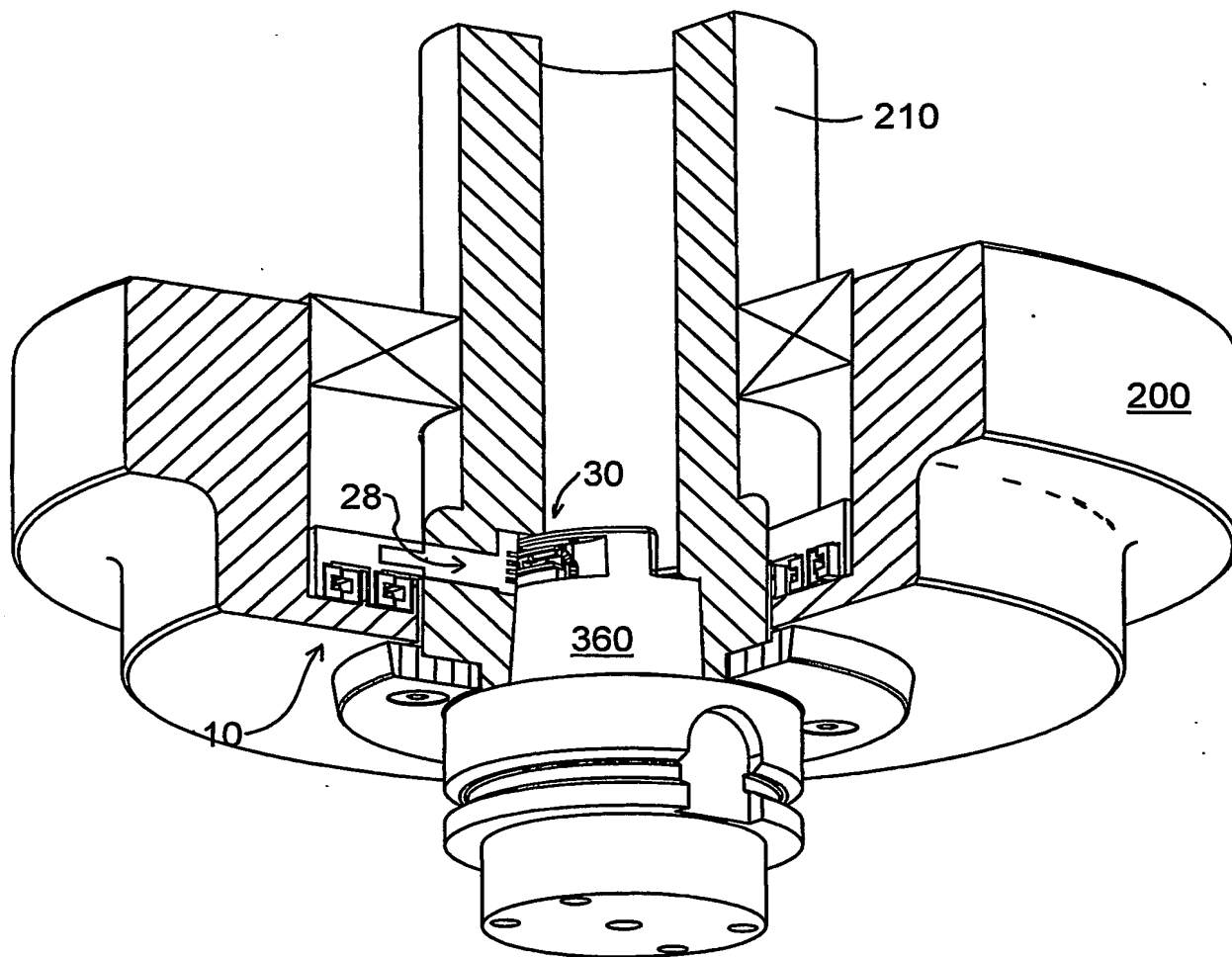
**Fig 18**

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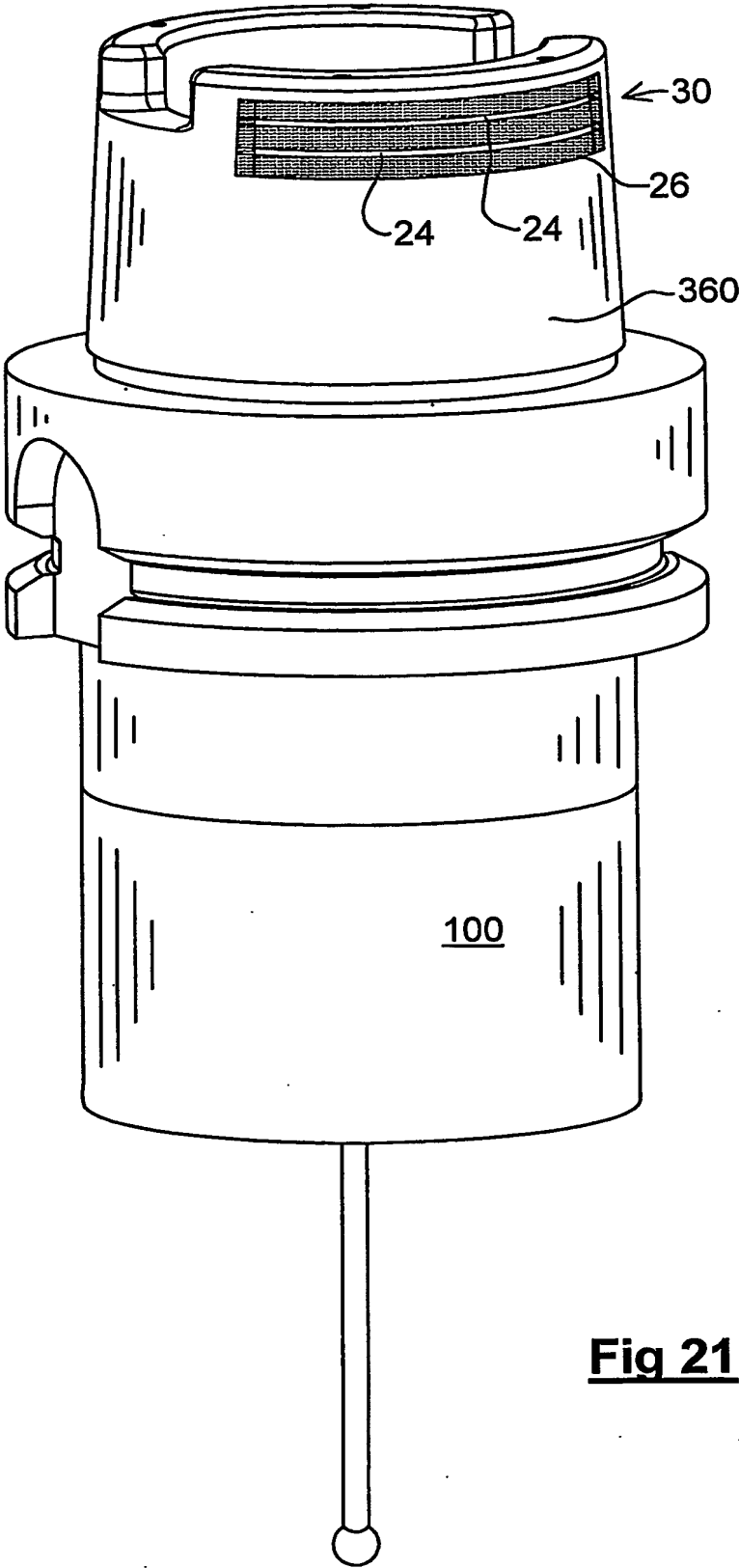
**Fig 19**



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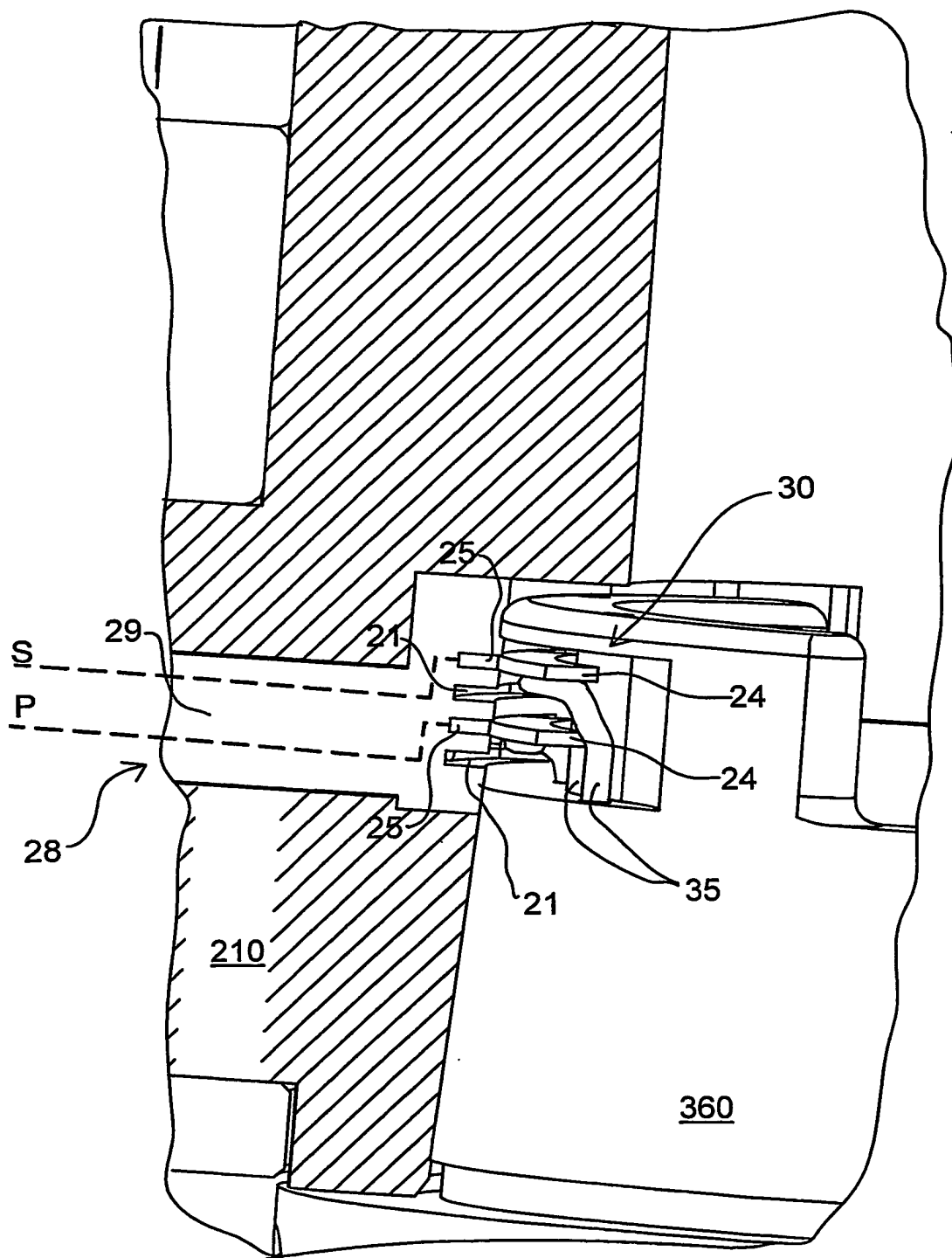
**Fig 20**

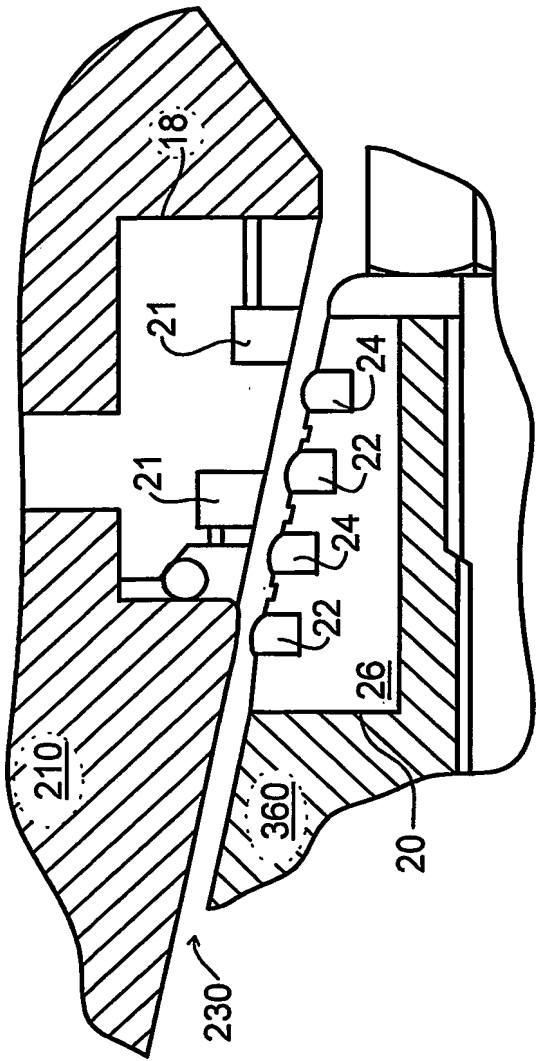
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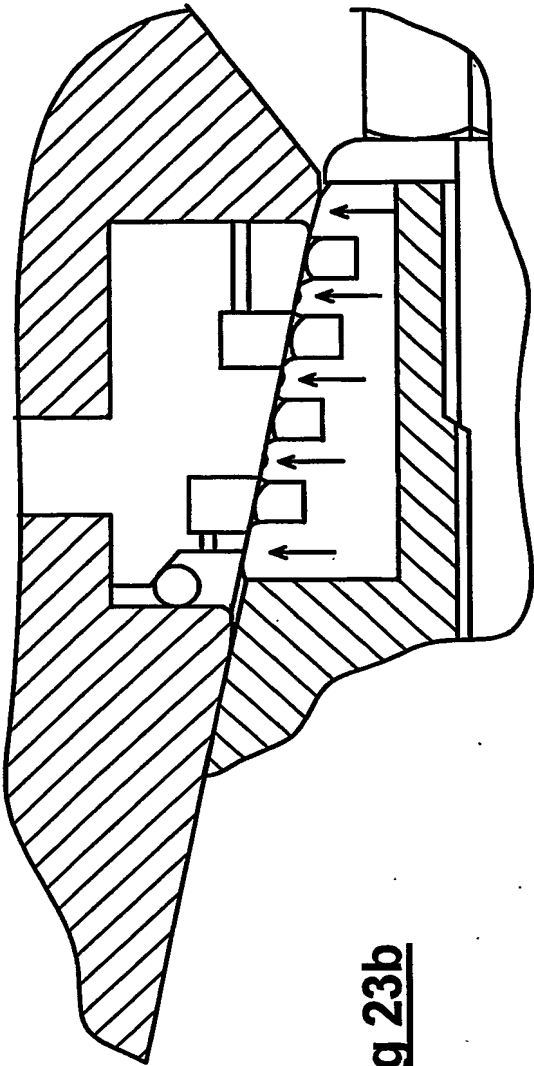
**Fig 21**

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**Fig 22**

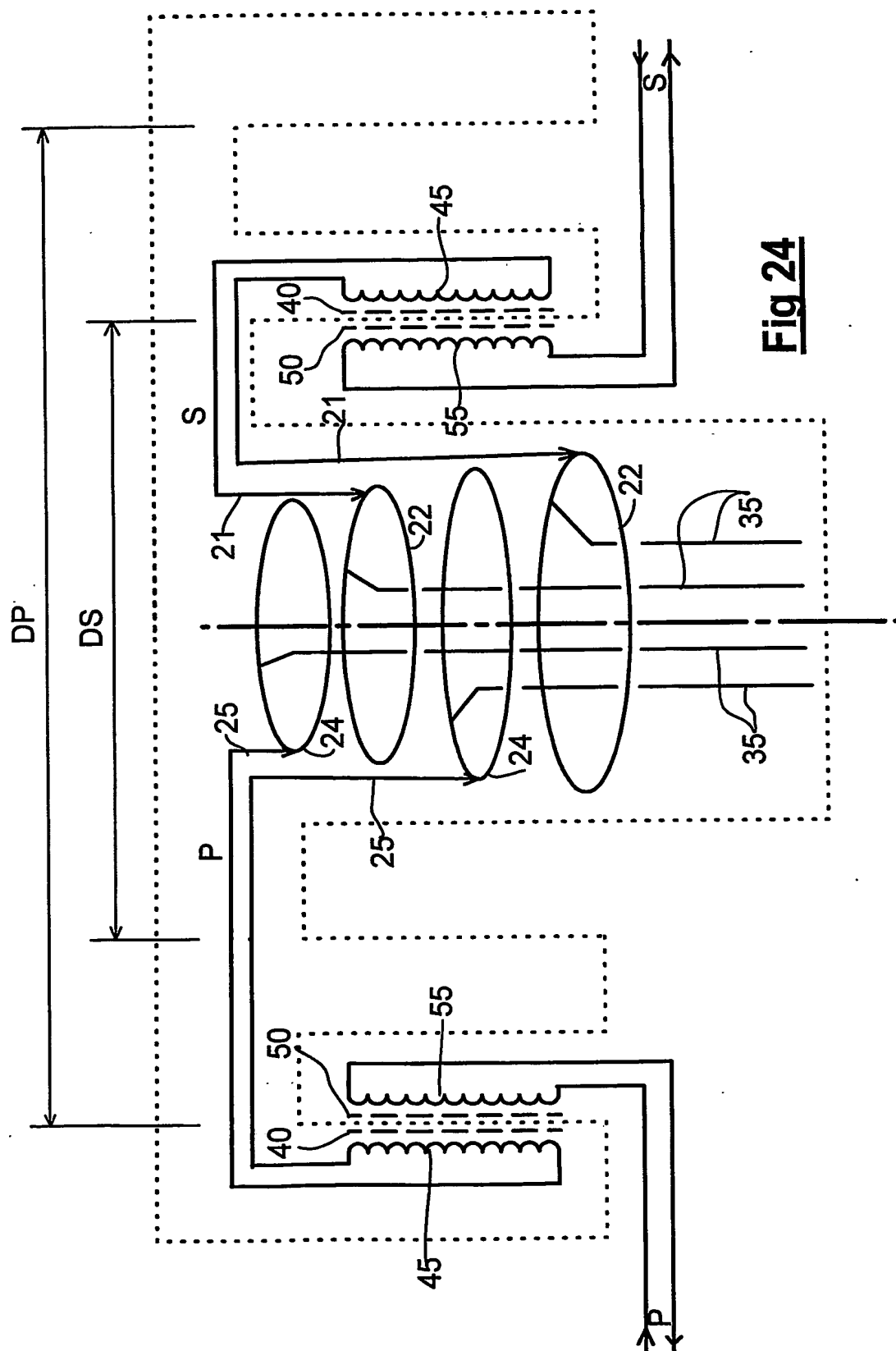


**Fig 23a**



**Fig 23b**

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/01677

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 B23Q1/00 B23Q3/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B23Q G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 504 691 A (MAUSER WERKE OBERNDORF) 23 September 1992 (1992-09-23)	1-3,5,6, 9,13-15, 17-22
Y	abstract; figures 5,6	4,10-12, 16
A	column 1, line 38 - line 51 column 3, line 33 -column 6, line 48 ---	7,8
X	EP 1 092 499 A (F M ELETTRMECCANICA S R L) 18 April 2001 (2001-04-18)  column 2, line 49 -column 4, line 55; figures 3,4  --- -/--	1-3,5,6, 9,13,15, 18-22

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

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- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
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\*8\* document member of the same patent family

Date of the actual completion of the international search

21 August 2003

Date of mailing of the international search report

01/09/2003

Name and mailing address of the ISA

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Authorized officer

Watson, S

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/01677

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 1 114 693 A (EMUGE WERK RICHARD GLIMPEL) 11 July 2001 (2001-07-11) paragraph '0015!; figure 1	10,16 1-9, 11-15, 17-22
Y	----- US 5 109 223 A (RITZ FRANZ ET AL) 28 April 1992 (1992-04-28) cited in the application column 4, line 6 - line 32; figure 1 -----	4,11,12

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 03/01677

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 0504691	A	23-09-1992	DE	9103229 U1	16-07-1992
			EP	0504691 A2	23-09-1992
EP 1092499	A	18-04-2001	IT	MI992150 A1	16-04-2001
			EP	1092499 A2	18-04-2001
			US	6554551 B1	29-04-2003
EP 1114693	A	11-07-2001	DE	10000174 A1	19-07-2001
			EP	1114693 A2	11-07-2001
US 5109223	A	28-04-1992	DE	3813949 A1	09-11-1989
			AT	65838 T	15-08-1991
			DE	58900197 D1	05-09-1991
			EP	0346562 A1	20-12-1989
			JP	1307602 A	12-12-1989



**Box No. VIII (iv) DECLARATION: INVENTORSHIP** (only for the purposes of the designation of the United States of America)  
*The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.*

**Declaration of inventorship (Rules 4.17(iv) and 51bis.1(a)(iv))  
 for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/982003/01677 (if furnishing declaration pursuant to Rule 26ter).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications: None

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

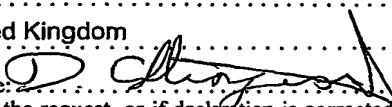
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: David Collingwood

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Citizenship: United Kingdom

Inventor's Signature:   
 (if not contained in the request, or if declaration is corrected or added under Rule 26ter after the filing of the international application. The signature must be that of the inventor, not that of the agent)


Date: 7<sup>th</sup> May 03  
 (of signature which is not contained in the request, or of the declaration that is corrected or added under Rule 26ter after the filing of the international application)

Name: Graham Richard Ferguson

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 United Kingdom

Citizenship: United Kingdom

Inventor's Signature:   
 (if not contained in the request, or if declaration is corrected or added under Rule 26ter after the filing of the international application. The signature must be that of the inventor, not that of the agent)

Date: 7<sup>th</sup> May 03  
 (of signature which is not contained in the request, or of the declaration that is corrected or added under Rule 26ter after the filing of the international application)

☒ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

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Name: Timothy Donald Hayter

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Inventor's Signature:  Date: 7th May 2003

Name: Tim Prestidge

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Inventor's Signature:  Date: 7th May 2003

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Citizenship: United Kingdom

Inventor's Signature:  Date: 9th May 2003

**Continuation of Box No. VIII (i) to (v) DECLARATION**

*If the space is insufficient in any of Boxes Nos. VIII (i) to (v) to furnish all the information, including in the case where more than two inventors are to be named in Box No. VIII (iv), in such case, write "Continuation of Box No. VIII ..." (indicate the item number of the Box) and furnish the information in the same manner as required for the purposes of the Box in which the space was insufficient. If additional space is needed in respect of two or more declarations, a separate continuation box must be used for each such declaration. If this Box is not used, this sheet should not be included in the request.*

**Continuation of Box VIII(iv)**

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Mailing Address: 1 Clare Walk, Thornbury, Bristol, South Gloucestershire,  
BS35 1EN, United Kingdom

Citizenship: United Kingdom

Inventor's Signature: D. K. Thomas Date: 7 May 2003